EHS Services and Solutions

Process Hazard Analysis

SB01 Facility

September 2020

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Attachments

Executive Summary

BSI EHS Services and Solutions (BSI) facilitated and documented a five-year revalidation Process Hazard Analysis (PHA) analysis for the existing Apple, Inc. (Apple) SB01 (Scott) facility in Santa Clara, California. The original PHA was performed by Environmental and Occupational Risk Management, Inc. in 2015 (acquired by BSI group).

The PHA revalidation process is a required component of the Risk Management Plan required for the facility pursuant to Title 19 of the California Code of Regulations (19 CCR), Division 2, Chapter 4.5, Section 2735 et seq.

A total of seven PHA groups, consisting of multiple nodes in table format, were included in the original PHA. The PHA team used the same PHA groupings and approach for the revalidation activities. PHA tables are attached to this report and organized in the following manner:

- Hazardous gases to include RMP regulated materials (ammonia, arsine, and chlorine)
  - HPM gas distribution systems
  - HPM precursors supporting MOCVD processes, both on-tool and any remote liquid and/or vapor delivery systems (if applicable)
  - Tool abatement and facility exhaust systems supporting process tools using HPM gases and organic precursors
- Hazardous liquids
  - HPM liquid distribution systems
  - Tool abatement and facility exhaust systems supporting process tools using HPM liquids
  - Wastewater treatment and collection system supporting HPM liquid waste lines to include collection tanks for concentrated waste (e.g., metals, photolithography/solvent waste) and onsite wastewater treatment system (e.g., Acid Waste Neutralization)
- Bulk ammonia system

For each node, the PHA team reviewed and discussed the original PHA boundaries and any changes to the systems. After a consensus was reached for each group and node, the PHA team discussed operating deviations caused by equipment malfunction, human error, and other failures (as noted in the *Causes* column of the PHA Summary tables). For operating deviations resulting in hazard, a qualitative evaluation was made of the effect of failure (as noted in the *Consequences* columns of the tables). Control measures, such as alarms, shutdown switches, operating and maintenance procedures, training, and inspections were discussed (as noted in the *Existing Safeguards* and *Protections* column of the tables). When applicable, open action items from the original PHA were covered to determine if closure had been achieved and if not, additional follow-up actions were identified. All action item closure from the original PHA session are documented in the *2020 Revalidation* column of the tables.

The review documented the type and set points for control devices and protective measures. When applicable, open action items from the original PHA were covered to determine if closure had been achieved and if not, additional follow-up actions were identified. Where inadequacies in control systems were noted for any newly identified inadequacies, the PHA team proposed actions.

In June 2017, modifications were made to two of the MOCVD systems, which are covered under a scope of the PHA. The systems involved were two tools, the Veeco K475i and the Axitron G4, and a separate Failure Modes and Effects (FMEA) study was conducted. It was decided by Apple and BSI to include a review of the FMEA during this five-year validation to synchronize schedules for future revalidations.

A description of the PHA methodologies and the results of the PHA are reflected in this document.

Introduction

BSI EHS Services and Solutions (BSI) facilitated and documented a five-year revalidation Process Hazard Analysis (PHA) analysis for the existing Apple, Inc. (Apple) SB01 (Scott) facility in Santa Clara, California. The original PHA was performed by Environmental and Occupational Risk Management, Inc. in 2015 (acquired by BSI group).

The PHA focused on:

- Hazardous gases to include RMP regulated materials (ammonia, arsine, and chlorine)
  - HPM gas distribution systems
  - HPM precursors supporting MOCVD processes, both on-tool and any remote liquid and/or vapor delivery systems (if applicable)
  - Tool abatement and facility exhaust systems supporting process tools using HPM gases and organic precursors
- Hazardous liquids
  - HPM liquid distribution systems
  - Tool abatement and facility exhaust systems supporting process tools using HPM liquids
  - Wastewater treatment and collection system supporting HPM liquid waste lines to include collection tanks for concentrated waste (e.g., metals, photolithography/solvent waste) and onsite wastewater treatment system (e.g., Acid Waste Neutralization)
- Bulk ammonia system

Based on the above grouping, BSI facilitated hazard analyses sessions to review hazards associated with the HPM inputs and outputs from the grouped sets of systems that could result from design error, operating error, equipment failure, or external events identified during the original PHA sessions and also identify any new conditions that should be evaluated.

The PHA was conducted in a manner appropriate to the complexity of the process. The PHA addressed the following elements:

- The original PHA boundaries and validity for the revalidation sessions
- Any changes to the covered process since completion of the original PHA
- Open action items from original PHA
- The hazards of the process
- The identification of any previous incidents which had a likely potential for catastrophic consequences
- Engineering and administrative controls applicable to the hazards, and their interrelationships, such as appropriate application of detection methods to provide early warning
- Consequences of failure of administrative and engineering controls
- Siting issues
- Human factors

- A qualitative evaluation of the range of possible health and safety effects of failure of controls

Subsequent sections of this report provide a summary of the review methods used and results, as well as a listing of corrective actions (recommendations) resulting from the PHA revalidation sessions. The PHA summary tables are presented within Attachments to this report.

Process Description

Process Overview

HPM hazardous gases, liquids, and MOCVD precursors are used in the research and development of computer equipment. Tool abatement, facility exhaust/treatment, and wastewater treatment/collection systems are in place to support process tools using HPM gases and organic precursors. Full system descriptions for the stationary source regulated substances represented in these PHA sessions are provided in the combined RMP document submitted to the Santa Clara Fire Department on September 4, 2015.

Piping & Instrumentation Diagrams (P&IDs) and Mechanical Schematics

The following P&ID drawings associated with the three regulated substances were referenced during the PHA sessions:

- Bulk ammonia system
  - pp7.01.1 (8/12/2015)
  - PP5.01.1 NH3 Bulk to 4-64
- 318173-Aria 2018 Master files (rev date 2/21/19), contains:
  - PP5.03.1, process piping AsH3 cylinders to MOCVD 4-68 and exhaust
  - PP5.03.2, process piping AsH3 cylinders to MOCVD 4-67 and exhaust
  - PP7.06.1- process piping 5% Cl2/N2
- Arsine system
  - PP7.03.1 – process piping AsH3 MOCVD room (rev date 8.12.15)
- Chlorine Processes
  - PP5.03.3 – Process piping PFD, Cl2 gas to MOCVD 4-68 (rev date 2/21/19)
  - 4-66 CL2 PFD rev C
- Abatement systems – Base TPU – fab TPU exhaust system – PM6.07.3 (rev date 9/18/15)
- New tool
  - PH-40 MOCVD 4-69 Fire – GLSS Record Drawing 06-01-20
  - PH-40 MOCVD Fire Dept Record Drawing 06-01-20

Additional PI&Ds where referenced for systems that are not considered part of the covered processes for purposes of the program level 3 RMP, but were requested to be covered in the PHA by the Authority Having Jurisdiction, the Santa Clara Fire Department, which included:

- AWN system (8/12/15) – PP6.20.1, PP6.20.2, PP6.20.3A, PP6.20.3B
- Acid waste lift stations (8/12/15) – PP6.25.1, PP6.25.2, PP6.25.3,
- Slurry lift stations (8/12/15) – PP6.24.1, PP6.24.2

- Slurry waste 2 lift stations (5/14/15) – PP6.24.4
- HMC collection system (2/10/15) – PP6.21.1, PP6.21.2, PP6.21.3
- HMR lift station (5/14/15) – PP6.22.1A, PP6.21.1B, PP6.22.2, PP6.22.3
- SW Collection system (2/10/15) – PP6.23.1, PP6.23.2,
- Recycle water (8/12/15) – PP6.31.1, PP6.31.2, PP6.31.3
- Grey water lift station (8/12/15) – PP6.31.1, PP6.31.2
- NEW - Evaporator (11/16/18) – PP6.30.1, pp6.22.1E

PHA Team

The team performing the PHA consisted of expertise in facility and chemical system design, installation, operation, maintenance, and environmental safety and health from Apple and BSI.

Facilitation and scribing resources were provided by the following BSI personnel:

- Steve Trammell, PE, CSP, CCPSC, CHMM and Principal Consultant
- Wendy Tredway, CHMM and Principal Consultant

PHA session participants are included in Appendix 2.

Assessment Methodology

Several hazard analysis methods are available as recommended by the American Institute of Chemical Engineers (AIChE) in their publication, *Guidelines for Hazard Evaluation Procedures*. In general, the complexity of the hazard analysis method chosen should reflect the complexity of the process. For the subject system, which involves piping and instrumentation and distinct system components, the hazard analysis methodology selected was What If? Hazard Analysis method. BSI briefly reviewed the hazard analysis methodologies with all members of the PHA team

What If? Hazard Assessment Methodology

A *What If* study convenes a cross-functional team to examine a system and the consequences of potential failures of equipment systems and procedures. To perform a What If study, the assessment team formulates and answers questions to evaluate the results of unexpected events due to the effects of external events, mechanical or instrumentation failures, or human errors. The concept uses questions that begin What if. For example, What if there is a power outage?

For each upset condition or deviation, a cause or causes and potential consequences were determined by the consensus of the PHA team. Protective devices were discussed. Based on the team's determination of the adequacy of protective devices for the severity of consequences, the team identified and documented preventive actions and mitigation strategies.

Design process parameters used during the PHA reviews included but were not limited to flow, pressure, temperature, time, media, and piping or tank containment. Guidewords used during the equipment review are provided in the following Table.

Design Parameters	Hazard Analysis Guide Words						
	More	Less	None	Part of	As well as	Other than	Reverse
Level	High Level	Low Level	No Level (Empty)	Low Interface	High Interface	Loss of Containment	
Pressure	High Pressure	Low Pressure	Open to Atmosphere	Partial Pressure			Vacuum
Flow	High Flow	Low Flow	No Flow	Missing Ingredient	Misdirection Impurities	Wrong Material	Back Flow
Temperature	High Temperature	Low Temperature	Freezing	Cryogenic			Auto-refrigeration
Composition or State	Additional Phase	Loss of Phase		Wrong Concentration	Contaminants	Wrong Material	Change of State
Reaction	High Reaction Rate (Runaway)	Low Reaction Rate (Slow)	No Reaction	Incomplete Reaction (Partial)	Side Reaction	Wrong Reaction	Decomposition
Time (Procedure)	Too Long	Too Short	Skipped or missing Step	Action Skipped	Extra Action (Shortcut)	Wrong Action	Out of Order
Sequence	Step Too Late	Step Too Early	Step Left Out	Step Left Out	Extra Action Included	Wrong Action Taken	Steps Backwards
Speed	Too Fast	Too Slow	Stopped	Out of Synch		Web or belt break	Backward
Agitation	Excessive Mixing	Poor Mixing	No Mixing	Mixing Interruption	Foaming		Phase Separation
Concentration	High Concentration	Low Concentration	Material Not Present		Additional Materials Present	Wrong Material Present	
Special	External Rupture	External Leak	Utility Failure	Tube Leak	Tube Rupture	Start/Stop Maintenance Sampling	Static

Failure Modes and Effects Analysis (FMEA)

FMEA is a qualitative and systematic tool which helps anticipate what might go wrong with a design or process. In addition to identifying how a design or process might fail and the effects of that failure, FMEA also helps find the possible causes of failure and assists the analysis team to discuss the likelihood of failures being detected before occurrence. During an FMEA , functional requirements or design parameters for discrete components or process steps are reviewed, and the study team asks initial questions such as:

- What can go wrong?
- Where will the variation come from?
- How can we prevent or control?

The team then discusses and records the potential failure modes, the effects of the failure mode, and causes or mechanisms of failure. The team also identifies existing design or process controls and how and in what manner a failure might be detected. At this point in the analysis, the team may decide to recommend additional controls or action to further mitigate potential risks. The format decided upon by the Apple and BSI review team is provided below:

bsi.

DESIGN FMEA WORKSHEET

PROJECT TITLE _____ **Drawing/Specification Reference:** _____
System: _____ **Company,Group,Site/Business Unit:** _____
Subsystem: _____ _____
Component: _____
Prepared By: _____ date _____
Core Team: _____

Item	Functional Requirement / Design Parameter	Potential Failure Mode	Potential Effect(s) of Failure	Potential Cause(s)/ Mechanisms	Current Design/ Process Controls	Recommended Action(s)

Node Selection

Based on a review of the original PHA report, changes to the covered processes, mechanical schematics, and discussion with the PHA Team, the PHA Facilitator proposed (and the team agreed upon) the following Groups and nodes. Minor modifications to the node grouping were made based on the following:

- Addition of an additional CS clean abatement system – Post Process Chamber to/through CS Clean Abatement and Oxidation Units
- Removal of tool 4-65 and installation of tool 4-69
- Installation of a distillation evaporator system to concentrate heavy metal bearing waste
- Group 3 nodes were condensed due to duplication of many controls and findings; nodes were grouped together as appropriate for each type of gas system

The groups and nodes were discussed with the PHA team and by consensus determined to be an appropriate grouping for conducting the PHA sessions.

Group 1: Hazardous Production Material (HPM) Gas Distribution Systems

- HPM Delivery by Vendor to the site's Shipping/Receiving area and transportation to the HPM Gas cabinet
- Installation/Hook up/Changeout in HPM Gas cabinet
- Dispensing from the Gas Cabinet via Auto Switchover Manifold Isolation Box (MIB) to Valve Manifold Box (VMB)
- Dispensing from the Valve Manifold Box (VMB) to the Tool and/or PEB
- RMP Focus – Arsine Gas Cabinet and Manifold (VMB)
- RMP Focus – Chlorine Gas Cabinet to Valve Manifold Box through PEB to Mixing Box

Group 2: HPM Precursors (Organometallics) Supporting MOCVD Processes, Both on-tool and Any Remote Liquid and/or Vapor Delivery Systems (If Applicable)

- HPM (MOCVD Source) Delivery by Vendor/Apple to the site's Shipping/Receiving area and Transportation to Temperature controlled Outside Storage Bunker
- Transport from the Temperature controlled Outside Storage Area to the MOCVD Tool(s)
- MOCVD Source Installation/Hook up/Change out
- Transport of used MOCVD source to temperature-controlled storage for return to vendor

Group 3: Tool Abatement and Facility Exhaust Systems Supporting Process Tools Using HPM Gases and MOCVD Sources

- Corrosive Gas HPM System – From Tool Vacuum Pump Discharge through Point of Use Abatement to Acid Exhaust Scrubber discharge to Atmosphere

- Flammable, Pyrophoric, MO source/Toxic HPM Systems – From Tool Vacuum Pump Discharge through Abatement (if Applicable) to Specific Exhaust System through Scrubber Discharge to Atmosphere
  - 2020 revalidation – Addition of CS Clean and oxidation system covered under FMEA review during June 2017. Revalidation conducted and included as a separate file under group 3.
- Ammonia Gas System – From Tool Vacuum Pump Discharge through Abatement to Exhaust system and Scrubber discharge to atmosphere

Group 4: Tool Abatement and Facility Exhaust Systems Supporting Process Tools Using HPM Gases and MOCVD Sources

- HPM Delivery by Vendor to the Site's Shipping/Receiving Area and Transportation to Storage Location by Apple Personnel
- Delivery of Chemical to Secondary Storage Location (e.g., flammable cabinet)
- Chemical Transport from Storage to Tool
- Chemical Reservoir Fill (Tool or Delivery Cabinet)
- Includes management of empty containers
- Dispense Cabinet to the Tool – includes CDUs located in Chases and tool enclosure "CDU" for MLO (metal lift off) IPA tool
- Process Equipment **– Not in Scope**

Group 5: Tool Abatement and Facility Exhaust Systems Supporting Process Tools Using HPM Liquids

- Scrubbed exhaust from tool(s) to scrubber
  - No POU abatement for liquid tools
- Solvent exhaust from tool to exhaust point
- Process Equipment **– Not in Scope**

Group 6: Wastewater System Supporting HPM Liquid Waste Lines to Include Collection Tanks For Concentrated Waste (e.g., Metals, Photolithography/Solvent Waste)

- Acid – Wet Etch, Plating, TPU/Scrubber blowdown – AWN pH Neutralization
- Heavy Metals rinse
- Photo Rinse – solvent collection
- Photo concentrate – local collection
- Solids Capture – local collection
- Tanker Haul away for collection tanks and waste drum haul off
- Chemical adds – Auto, Manual, Truck delivery
- Softener Backwash

Group 7: Bulk Ammonia

- Disconnection of Used Columbianas, Delivery by Distributor and Hook Up of new Columbianas
- Columbiana and Columbiana Enclosures
- Purge Block
- High Pressure Block
- Vaporizer
- Low-Pressure Delivery to the Tool (through a main purifier, valve manifold box (VMB) and Point of Use Purifier
- Global What-If Node

For each node, the team reviewed the following by consensus:

- The applicable design parameters (e.g., flow rate, pressure, temperature, as applicable)
- Potential deviations for each parameter based on guidewords (such as “low,” “high,” and “breach,” as applicable)
- The anticipated cause(s) and potential consequence(s) of each deviation
- The relevant protection measures and actions required if the current level of protection is not adequate for the magnitude of the potential consequence (as determined by the PHA team)

Note to Fire Department – What If? Hazard Analysis Tables for Group 2, 4, 5 and 6 have been removed as they do not pertain directly to the three regulated materials (Ammonia, Arsine, and Chlorine).

Previous Incidents

There have been no releases or accident related to the storage, handling, and use of hazardous production materials since the systems came online.

Controls Applicable to Hazards and Consequences of Control Failure

For each node, the PHA team discussed operating deviations caused by equipment malfunction, human error, and other failures (as noted in the *Causes* column of the PHA Summary Tables). For operating deviations resulting in hazard, a qualitative evaluation was made of the effect of failure (as noted in the *Consequences* column of the Tables). Control measures, such as alarms, shutdown switches, operating and maintenance procedures, training, and inspections were discussed (as noted in the *Protection* column of the Tables). The review documented the type and set points for control devices and protective measures. Where changes to the covered processes and/or inadequacies in control systems were noted, the PHA team proposed actions, which are documented in the *Comments and Actions* column of the PHA Review Tables.

Original PHA Action Item Closure

The PHA team reviewed action items from the original PHA session and documented verification of action item closure within the PHA tables. If an action item was affected by a change to the process or determined to be inadequate, new/follow up actions were created if deemed necessary by consensus of the PHA Team. In the PHA table, closed actions are marked as "**PHA team verified action closed:"** in the *2020 Revalidation* column of the PHA review tables.

New Action Item Determination

The PHA team reviewed changes to the covered processes and action item closure that occurred since the original PHA sessions conducted during the design/build phase of the facility. Where changes to the covered processes, open action items and/or inadequacies in control systems were noted, the PHA team proposed actions and documented in the node notes or the *2020 Revalidation* column of the PHA review tables. Original 2015 action items are documented in the *Original 2015 Recommendations* column of the PHA review table, with closure for those actions tracked in the *2020 Revalidation* column.

Results

Summary Documentation

The tables presented in Attachments 1 through 7 summarize PHA session discussions and team consensus, including action items. This documentation represents the statements and consensus of the session, discussion, and review participants. BSI did not investigate the veracity of the statements made by the participants during the assessment, and accepts no liability for issues, which were not identified during the assessment and which are later found to pose hazardous consequence

Review, Update, and Recordkeeping Requirements

Pursuant to the RMP and CalARP requirements, at least once every five years, the PHA shall be updated and revalidated by an appropriate team to ensure it is consistent with the current process. Changes in the overall system will be per Apple's Management of Change program that will assist in the next PHA Validation process during the second five-year cycle in 2025.

Action Item Summary List

Several actions to reduce the potential for deviation or hazard were identified during this review. Each action is listed in the *2020 Revalidation* column of the PHA Summary Tables. To facilitate tracking of action item completion, the action items documented on the PHA Session Worksheets and tracked for completion in the Action Item Summary List referenced in Appendix 3.

Attachment 1: Group 1 – Hazardous Production Material (HPM) Gas Distribution Systems

Nodes included

- HPM Delivery by Vendor to the site's Shipping/Receiving area and transportation to the HPM Gas cabinet
- Installation/Hook up/Changeout in HPM Gas cabinet
- Dispensing from the Gas Cabinet via Auto Switchover Manifold Isolation Box (MIB) to Valve Manifold Box (VMB)
- Dispensing from the Valve Manifold Box (VMB) to the Tool and/or PEB
- RMP Focus – Arsine Gas Cabinet and Manifold (VMB)
- RMP Focus - Chlorine Gas Cabinet to Valve Manifold Box through PEB to Mixing Box

Apple SB01 2020 Group 1 PHA.pdf

Attachment 2: Group 2 – HPM Precursors (Organometallics) Supporting MOCVD Processes, Both On-Tool and Any Remote Liquid and/or Vapor Delivery Systems (If Applicable)

Nodes Included

- HPM (MOCVD Source) Delivery by Vendor/Apple to the site's Shipping/Receiving area and Transportation to Temperature controlled Outside Storage Bunker
- Transport from the Temperature controlled Outside Storage Area to the MOCVD Tool(s)
- MOCVD Source Installation/Hook up/Change out
- Transport of used MOCVD source to temperature-controlled storage for return to vendor

Note to Fire Department – What If? Hazard Analysis Tables for Group 2, 4, 5 and 6 have been removed as they do not pertain directly to the three regulated materials (Ammonia, Arsine and Chlorine).

Attachment 3: Group 3 – Tool Abatement and Facility Exhaust Systems Supporting Process Tools Using HPM Gases and MOCVD Sources

What if PHA Nodes included:

- Corrosive Gas HPM System – From Tool Vacuum Pump Discharge through Point of Use Abatement to Acid Exhaust Scrubber discharge to Atmosphere
- Flammable, Pyrophoric, MO source/Toxic HPM Systems – From Tool Vacuum Pump Discharge through Abatement (if Applicable) to Specific Exhaust System through Scrubber Discharge to Atmosphere
  - 2020 revalidation – Addition of CS Clean and oxidation system covered under FMEA review during June 2017
- Ammonia Gas System – From Tool Vacuum Pump Discharge through Abatement to Exhaust system and Scrubber discharge to atmosphere

An FMEA was initially performed in June 2017, to study risks related to changes in post process piping and abatement system addition, for the VECCO MOCVD (tool # 4-67), and the Aixtron G4 MOCVD (tool # 4-68). Specifically, additions were made to add a controlled oxidation system to the post process piping and exhaust system of the tools, which is designed to safely remove partially or un-reacted by-products which may still exhibit highly energetic properties. Also, a second dry scrubber system from CS Cleans was added, to provide added capacity and redundancy to the originally designed and installed abatement units. The FMEA focused on these additions and resulting tables are provided below, in addition to the 2020 revalidation and review of action item closure status.


Apple SB01 2020 Group 3 PHA.pdf


FMEA.pdf


FMEA update - QCS add to 2020 PHA rev

Attachment 4: Group 4 – Tool Abatement and Facility Exhaust Systems Supporting Process Tools Using HPM Gases and MOCVD Sources

Nodes included:

- HPM Delivery by Vendor to the Site's Shipping/Receiving Area and Transportation to Storage Location by Apple Personnel
- Delivery of Chemical to Secondary Storage Location (e.g., flammable cabinet)
- Chemical Transport from Storage to Tool
- Chemical Reservoir Fill (Tool or Delivery Cabinet)
- Includes management of empty containers
- Dispense Cabinet to the Tool – includes CDUs located in Chases and tool enclosure "CDU" for MLO (metal lift off) IPA tool
- Process Equipment – **Not in Scope**

Note to Fire Department – What If? Hazard Analysis Tables for Group 2, 4, 5 and 6 have been removed as they do not pertain directly to the three regulated materials (Ammonia, Arsine and Chlorine).

Attachment 5: Group 5 – Tool Abatement and Facility Exhaust Systems Supporting Process Tools Using HPM Liquids

Nodes Included:

- Scrubbed exhaust from tool(s) to scrubber
  - No POU abatement for liquid tools
- Solvent exhaust from tool to exhaust point
- Process Equipment – Not in Scope

Note to Fire Department – What If? Hazard Analysis Tables for Group 2, 4, 5 and 6 have been removed as they do not pertain directly to the three regulated materials (Ammonia, Arsine and Chlorine).

Attachment 6: Group 6 – Wastewater System Supporting HPM Liquid Waste Lines to Include Collection Tanks for Concentrated Waste (e.g., Metals, Photolithography/Solvent Waste)

Nodes Included:

- Acid – Wet Etch, Plating, TPU/Scrubber blowdown – AWN pH Neutralization
- Heavy metals rinse
- Photo Rinse – solvent collection
- Photo concentrate – local collection
- Solids Capture – local collection
- Tanker Haul away for collection tanks and waste drum haul off
- Chemical adds – Auto, Manual, Truck delivery
- Softener Backwash

Note to Fire Department – What If? Hazard Analysis Tables for Group 2, 4, 5 and 6 have been removed as they do not pertain directly to the three regulated materials (Ammonia, Arsine and Chlorine).

Attachment 7: Group 7 – Bulk Ammonia

Nodes Included:

- Disconnection of Used Columbianas, Delivery by Distributor and Hook Up of new Columbianas
- Columbiana and Columbiana Enclosures
- Purge Block
- High Pressure Block
- Vaporizer
- Low Pressure Delivery to the Tool (through a main purifier, valve manifold box (VMB) and Point of Use Purifier
- Global What-If Node

Apple SB01 2020 Group 7 PHA.pdf

Appendix 1: P&IDs

All available on Apple internal BOX folder

Appendix 2: PHA Session Sign-In Sheets

Appendix 2 - sign in sheets.pdf

Appendix 3: PHA Action Item Summary Table


action item
summary 2015 & 202


Action Item
Summary 2015 & 202

Appendix 4: PHA Facilitator and Scribe Qualifications


Tredway W.pdf


Trammell S.pdf